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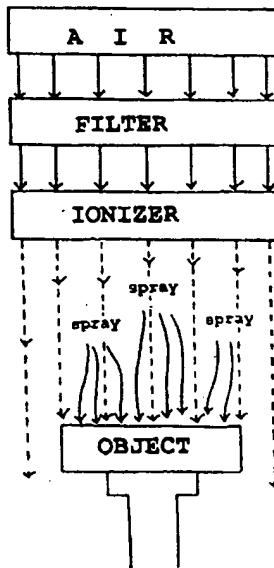
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### (54) A method and an apparatus for adhering particles to an object by supplying air ions

(57) The present invention relates to a method and an apparatus for adhering particles on an object to form a coating thereon. The particles are sprayed onto the object in which the air ions comprising positive air ions and negative air ions are continuously supplied to both sprayed particles in an atmosphere and a surface of the object to be coated during a spraying operation. The apparatus comprises a chamber for accommodating the object and an air ionizer which is provided at a ceiling or a side wall of the chamber, and the ionizer receives an air from the outside of the chamber and produce the positive and negative air ions to supply in the chamber.

FIG. 2



EP 0 885 662 A1

**Description****FIELD OF THE INVENTION**

5 This invention relates to a method and an apparatus for adhering particles to an object to form a coating thereon and more particularly to a method and an apparatus for spraying paint particles to the object. In the specification, an explanation of the invention is directed to a painting but the idea of the invention is applicable to other technique which includes a printing, an adhesion for example.

**10 BACKGROUND OF THE INVENTION**

15 For a painting, a good finishing of coating and a good efficiency of adhesion of paint particles are required. An electrostatic painting is widely used to acquire the latter requirement in which a paint spray gun is to be charged by a first potential and the spray gun emits charged paint particles, a target to be painted is to be charged by a second potential so that the electrically charged paint particles emitted by the spray gun have a first electric force applied to them urging the electrically charged paint particles toward the target. According to the electrostatic painting, the efficiency of adhesion of particles is increased and an amount of waste particles is greatly reduced.

20 It is, however, that according to the electrostatic painting, a force of collision between the particles and the target is strong so that a forming of an adhesion layer is rough which results in a bad finishing of a surface. In addition, safety measures add substantially to the cost, complexity and bulk of the electrostatic painting apparatus.

25 The present invention is mainly directed to provide a new method and an apparatus for adhering particles to the object in which, by supplying air ions, the good finishing of coating is obtained and the efficiency of adhesion is improved.

30 Generally, the air ions are used to neutralize the static charges. It is well known that a high concentration of both types of air ions acts to suppress accumulations of static electricity on objects to be coated. Static electrical charges attract air ions of the opposite polarity and the attracted ions then neutralize the static charges. In a pre-painting process, a use of ionizer which produce both positive and negative ions is known. For example, a spray booth in which the air ions are introduced into a chamber to neutralize and suppress a static electric charge and prevent a dust from clinging to an object to be coated is disclosed in Japanese laid-open patent No. 8-84948 and Japanese Utility Model Registration No. 3018050.

**SUMMARY OF THE INVENTION**

35 According to the present invention, in a method for adhering particles on an object to form a coating thereon, particles are sprayed to the object in which air ions comprising positive air ions and negative air ions are continuously supplied to both sprayed particles in an atmosphere and the surface to be painted. The present method is different from the prior arts in above-mentioned Japanese documents in that the air ions are continuously supplied during a spraying operation. According to the present method, the coating of good finishing and the good adhesion between particles themselves and between the particles and the surface to be coated are obtained.

40 It is believed that the air ions comprising the positive and the negative air ions affect the paint particles and the surface to be painted somehow thereby contributing to the good adhesion between the particles and the surface to be coated and the good adhesion between particles themselves. The wetting property of the surface may be improved by continuously supplying the air ions to the surface. The sprayed particles in the atmosphere may be charged by continuously supplying air ions to the sprayed particles and the charged particles are electrostatically attracted each other resulting in the good adhesion between the particles. The surface (which includes a surface of layer of painted particles as well as the surface of the object) may be charged by continuously supplying the air ions to the surface. Considering the fact that a thickness of the coating of paint particles of the present invention is thicker than that of normal spraying, other spraying conditions being equal, an electrostatic force may be something to do with the formation of coating.

45 Though the mechanism of formation of coating is not clearly understood, according to a hypothesis, the particle is charged in which the particle has both a positive electrostatic charge and a negative electrostatic charge at opposite positions each other. The particle which normally has a positive electric charge at first when it is sprayed may be neutralized by the negative ion, but by continuously supplying positive and negative ions to the particle, the particle may be charged according to Fig. 1 (a) and portions of opposite electric charges attract each other to form a layer as shown in Fig. 1(b). According to this hypothesis, it is desirable to supply equal numbers of positive and negative ions to the particles and the surface to be painted.

50 The object to be coated is made of any materials such as metal, wood, plastic, paper and the like. The particles are made of water-soluble paint particle, powder paint particle, organic-soluble paint particle, ink and the like. It is found that the organic-soluble paint particle and the powder paint particle are preferably selected. It is found that in case of the

water-soluble paint particles, preferably, the positive ions and the negative ions are alternately supplied to the particles at predetermined interval, a few seconds for example. Preferably, an air-less spray such as a centrifugal spray is selected. In case of an air spray, the air ions may be diluted by a sprayed air.

According to the present invention, a spray booth apparatus for spraying particles to an object by continuously supplying air ions of positive air ions and negative air ions, the apparatus comprises a chamber for accommodating the object and an air ioniser which is provided in a ceiling or a side wall of the chamber to supply both the positive air ions and the negative air ions in the chamber.

Preferably, the ionizer comprises at least a pair of air ionizing electrodes and a D.C. voltage supply which produces both positive and negative high voltages to apply voltages of opposite polarities to the ionizing electrodes. According to a D.C. voltage type ionizer, it is easier to control a ratio of the production of the positive ions and the negative ions.

More preferably, the ionizer further comprises means for interchanging the polarities of said ionizing electrodes at a predetermined interval. An erosion of the positive electrode progresses faster than that of the negative electrode because molecules are collided with the positive electrode at the time of corona discharging. Because of the interchange of the polarities of the electrodes, the electrode erosion of both electrodes are averaged thereby preventing an imbalance of production of positive and negative ions and prolonging the life of the electrodes. In addition, the interchange of the polarities of the electrodes prevents the dust from clinging to the electrodes.

In another aspect of the invention, the ionizer comprises at least one air ionizing electrode, a D.C. voltage supply which produces both positive and negative high voltages to apply a voltage of either of polarity to the ionizing electrode and means for interchanging the polarity of the ionizing electrode at a predetermined interval. This type of ionizer is preferably used for the water-soluble particles.

According to the method of the present invention, the coating having a strength is obtained because of the good adhesion between the particles. Accordingly, by spraying particles on the surface of liquid such as water, the coating is formed on the surface. The coating may be removed from the surface and obtained as a film. Alternatively, by pressing an object onto the coating, the coating is transferred to the surface of the object by a liquid pressure.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

- Fig.1 shows a model of charged particles in an atmosphere comprising positive air ions and negative air ions.
- Fig.2 is a schematic view showing a method of the present invention.
- 30 Fig.3 (a), (b) are side elevations showing two types of spray booths.
- Fig.4 is a perspective view of a charging unit of an air ionizer of the present invention.
- Fig.5 is a perspective view showing a control unit of an air ionizer of the present invention.
- Fig.6 shows interchanges of polarities of electrodes.
- Fig.7 shows a high voltage supply.
- 35 Fig.8 is a circuit diagram showing a first embodiment of the interchanges of polarities.
- Fig.9 is a circuit diagram showing a second embodiment of the interchanges of polarities.
- Fig.10 shows another embodiment of a method for coating.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

40 Fig.2 shows a painting method of the present invention. An air introduced is cleaned by an air filter and is ionized by an air ionizer and positive air ions and negative air ions are produced. The positive air ions and the negative air ions are supplied to a surface of an object to be painted. Then paint particles are sprayed to the surface of the object. During a spraying operation, the air ions comprising the positive air ions and the negative air ions are continuously supplied to both sprayed particles in the atmosphere and the surface to be coated.

45 As shown in Fig. 3, a spray booth comprises a chamber 1 for accommodating the object to be coated, an air inlet 2 and an air outlet 3, and the air ionizer 4 which is provided in a ceiling of the chamber 1 and is adapted to receive the air from the outside of the chamber 1 to generate both positive and negative ions and supply them into the chamber 1. Preferably, the air introduced is cleaned by an air filter. In the chamber 1, the object is placed to receive an ion shower.

50 In case of a spray booth, by continuously supplying the air ions, the chamber 1 is filled with air ions and an atmosphere comprising positive ions and negative ions is obtained. When the paint particles are sprayed in that atmosphere, the air ions are supplied to the sprayed particles.

The air ionizer 4 comprises a charging unit 5 which is provided in an upper wall and/or a side wall of the chamber 1 and a power control unit 6 which is separated from the charging unit 5 and is provided outside the chamber 1.

55 The charging unit 5 comprises four discharging wires 7 which constitute ionizing electrodes and cartridges 8 accommodating the electrodes, first supporting members 9 which extend along with the cartridges 8, second and third supporting members 10, 11 which extend substantially perpendicularly to the first supporting members 9 and a D.C. voltage supply which produces both positive and negative high voltages to apply voltages of opposite polarities to the

ionizing electrodes. The electrodes are spaced apart and are paralleled each other. Upper portions of the cartridges 8 are supported by the first supporting members 9. One ends of the first supporting members 9 are supported by the second supporting member 10 and the other ends of the first supporting members 9 are supported by the third supporting member 11.

5 The first and the second supporting members 9, 10 have a hollow portion therein and one ends of the first supporting members 9 are open ends and communicate with the second supporting member 10. The second supporting member 10 has a closed end and an open end and the open end is provided with an air hose 12 which supply an air from the outside of the chamber 1. The elongate cartridge a which accommodates the electrode has a slit 8a which is provided at lower portion of the cartridge 8 and is extended in an extending direction of the wire 7. The electrode wire 7 is made of tungsten having a diameter of 60 micron and has an Au plating.

10 The first supporting members 9 are slidably mounted at the second and the third supporting members 10, 11 in extending directions of the second and the third supporting members 10, 11. Therefore, spaces between the electrodes can be selected in accordance with the object to be coated.

15 The power control unit 6 comprises a blower 13, a filter 14, a control panel 15 and an air inlet. The air flow created by the blower 13 is supplied to the charging unit 5 via the air hose 12. A rotation of blower 13 and a charging of the electrode are synchronized so that the entry of paint particles to the cartridge 8 is prevented. An amount of air flow is also adjustable by controlling the rotation of the blower 13.

20 The ionizer 4 of the embodiment is a D.C. voltage type ionizer in which the electrode wire 7 becomes a positive electrode by charging a positive D.C. voltage bias and the electrode wire 7 becomes a negative electrode by charging a negative D.C. voltage bias. If two of the four wires 7 are charged by the positive voltage and the rest two wires 7 are charged by the negative voltage, the ionizer 4 produces both the positive ions and the negative ions at the same time.

25 The high voltage supply comprises a pair of transformers and the primary windings of transformers receive direct currents and alternating currents are obtained at the secondary windings of the transformers. The secondary windings are connected to electrodes via multiplying and rectifying circuits 16a, 16b which comprise a plurality of capacitors 17 and diodes 18 so that a high D.C. voltage of either polarity is applied to the electrodes.

30 According to the air ionizer 4 of the present invention, the ionizer 4 comprises means for interchanging the polarity of the electrodes at a predetermined interval. A relay for switching the polarity of D.C. current voltage which is to be applied to the electrodes is comprised of a make contact 19a and a break contact 19b. When the make contact 19a is open, the break contact 19b is closed and vice versa. When the make contact 19a is closed, a switch 20a is switched on and a contact 21a for RL2 is closed so that the negative high D.C. voltage is applied to the electrodes. When the break contact 19b is closed, a switch 20b is switched on and a contact 21b for RL1 is closed so that the positive high D.C. voltage is applied to the electrodes. In this regard, Fig.8 shows four electrodes and two a pair of high voltage supplies in which two electrodes are connected to a first high voltage supply of a first polarity and the rest two electrodes are connected to a second high voltage supply of a second polarity. Fig.9 shows four electrodes which are connected to a high voltage supply in which high D.C. voltage of either polarity is applied to all electrodes at the same time. Fig.6 shows interchanges of polarity of electrodes in which (a) corresponds to the circuit of Fig.9 and (b) corresponds to the circuit of Fig.8.

35 Fig.10 shows another embodiment of a method for coating. In this embodiment, particles are sprayed on a surface of a liquid 22 such as water and a coating 23 is formed on the surface which is regarded as a first object. The coating 23 may be removed from the surface and obtained as a film. Alternatively, a second object 24 is pressed onto the coating 23 and the coating 23 is transferred to the surface of the second object 24 by a liquid pressure. The liquid 22 is preferably selected according to the specific gravity of the coating particles and in most cases, the water is preferably selected. The coating 23 may be comprised of layers in which a first layer of the surface is a clear coating, a second layer on the first layer is an enamel coating and a third layer on the top is a primer coating.

45 **example 1**

table 1

50

	sample 1	sample 2
gloss	85.3 degrees	93.2 degrees
hardness	HB	2H

table 1 (continued)

	sample 1	sample 2
adhesion particulars	100/100	100/100
5 (1)substrate: ABS resin (sample 1 and sample 2)		
(2)spray condition:		
sample 1: an air atmosphere, 25 degrees Celsius, 55% humidity /enamel paint - 10 minutes' setting - clear paint-drying (60 minutes, 70 degrees Celsius)		
10 sample 2: an air atmosphere, 25 degrees Celsius, 55% humidity + continuously supplying both positive air ions and negative air ions during spraying operation/enamel paint - 10 minutes' setting - clear paint- drying (60 minutes, 70 degrees Celsius)		
(3)gloss: 60 degrees mirror surface reflection rate/ the digital deflection angle gloss measuring instrument(UGV-50 type Suga)		
15 (4)hardness: the pencil scratching instrument using Mitsubishi uni (Toyo Seiki)		
(5)adhesion: gobanme test after 240 hours in the water 40 degrees Celsius/ the cross cut guide (Kotex)		

Those examinations correspond to JIS(Japanese Industrial Standard) K 5400. As shown in the table 1, sample 2 has advantages in gloss and hardness. Though the result of adhesion is the same according to this test, it does not mean that the strength of adhesion of sample 1 and sample 2 are equal.

### Example 2

table 2

	sample 1	sample 2
thickness particulars	40 micron	70 micron
25 (1)substrate: ABS resin of 20cm X 30 cm		
30 (2)coating: enamel paint (30g), clear paint (30g)		
(3)spraying condition		
sample 1: enamel paint - 10 minutes' setting - clear paint- drying ( 60 minutes, 60 degrees Celsius)- setting time 2 hours		
35 sample 2: continuously supplying both positive air ions and negative air ions during spraying operation/enamel paint - 10 minutes' setting - clear paint- drying ( 60 minutes, 60 degrees Celsius)-setting time 2 hours		

The result of the example 2 shows that the present method has an advantage in forming a thicker coating.

According to the example 1 and 2, substantially equal numbers of positive and negative air ions are supplied. However, the ratio of the positive and the negative air ions is not limited to the example. Some imbalances of the positive and the negative ions are tolerable to obtain a preferable result compared with the normal spray coating.

### Claims

45 1. A method for adhering particles on an object to form a coating thereon, said method comprising:

spraying the particles onto the object; and  
continuously supplying air ions comprising positive air ions and negative air ions to both sprayed particles in an atmosphere and a surface of the object to be coated during a spraying operation.

50 2. The method as claimed in claim 1, said method comprising:

accommodating the substrate in a chamber;  
continuously supplying the air ions comprising the positive air ions and the negative air ions in said chamber and obtaining an atmosphere comprising the positive air ions and the negative air ions in said chamber; and  
spraying the particles to the object in said atmosphere.

55 3. The method as claimed in claim 1, wherein said particles are water-soluble and the positive air ions and the nega-

tive air ions are alternately supplied to the sprayed particles and the object at a predetermined interval.

4. The method as claimed in claim 1, wherein the air ions are supplied by an air ionizer which produce both the positive air ions and the negative air ions.
5. The method as claimed in claim 4, wherein said ioniser comprises at least a pair of air ionizing electrodes and a D.C. high voltage supply which produces both positive and negative high voltages to apply voltages of opposite polarities to said ionizing electrodes.
10. The method as claimed in claim 5, said ionizer further comprising means for interchanging the polarities of said ionizing electrodes at a predetermined interval.
15. The method as claimed in claim 3, wherein the air ions are supplied by an air ionizer which comprises at least one air ionizing electrode, a D.C. high voltage supply producing both positive and negative high voltages to apply a voltage of either of polarity to said ionizing electrode and means for interchanging the polarity of said ionizing electrode at a predetermined interval.
20. The method as claimed in claim 1, wherein the particles are sprayed on a surface of liquid to form the coating on the surface.
25. The method as claimed in claim 8, wherein an object is pressed onto the surface of the liquid and the coating is transferred to a surface of the object by a liquid pressure.
- 10: A spray booth apparatus for spraying particles to an object by continuously supplying air ions of positive and negative air ions, said apparatus comprising:
  - a chamber for accommodating the object; and
  - an air ionizer which is provided at a ceiling or a side wall of the chamber, and said ionizer receives an air from an outside of the chamber and produce the positive and negative air ions to supply in said chamber.
30. 11. The apparatus as claimed in claim 8, wherein said ionizer comprises at least a pair of air ionizing electrodes and a D.C. high voltage supply which produces both positive and negative high voltages to apply voltages of opposite polarities to said ionizing electrodes.
35. 12. The apparatus as claimed in claim 9, said ionizer further comprising means for interchanging the polarities of said ionizing electrodes at a predetermined interval.
40. 13. The apparatus as claimed in claim 8, wherein said ionizer comprises at least one air ionizing electrode, a D.C. high voltage supply producing both positive and negative high voltages to apply a voltage of either of polarity to said ionizing electrode and means for interchanging the polarity of said ionizing electrode at a predetermined interval.
45. 14. The apparatus as claimed in claim 8, wherein said ionizer comprises a plurality of wire electrodes which are accommodated in elongate cartridges and each said cartridges has a slit which extends in a longitudinal direction of said cartridge and faces downwardly to inject the air ions therethrough.
15. The apparatus as claimed in claim 14, wherein upper portions of said each cartridges are fixed to first supporting members having hollow portions, said cartridges and said first supporting members are communicated and the air is introduced to said electrodes via the hollow portions of the first supporting members.
50. 16. The apparatus as claimed in claim 15, wherein one ends of the first supporting members are fixed to a second supporting member which extends perpendicularly to the first supporting members and has a hollow portion, the first supporting members and the second supporting member are communicated and an air hose which introduces the air from the outside of the chamber is connected to one end of the second supporting member.
55. 17. The apparatus as claimed in claim 16, wherein an air blower is provided adjacent to an air inlet to introduce the air to the electrodes.
18. The apparatus as claimed in claim 17, wherein a rotation of the air blower and a charging of the electrode are syn-

chronized.

19. The apparatus as claimed in claim 17, wherein an air filter is provided at the air inlet to clean the air which is to be supplied to the electrodes.

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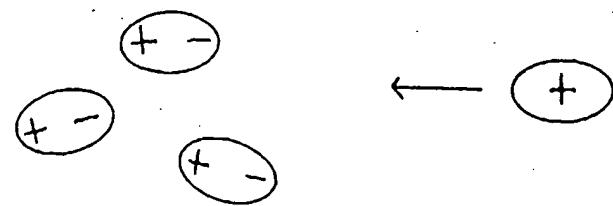
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FIG. 1

(a)



(b)



FIG. 2

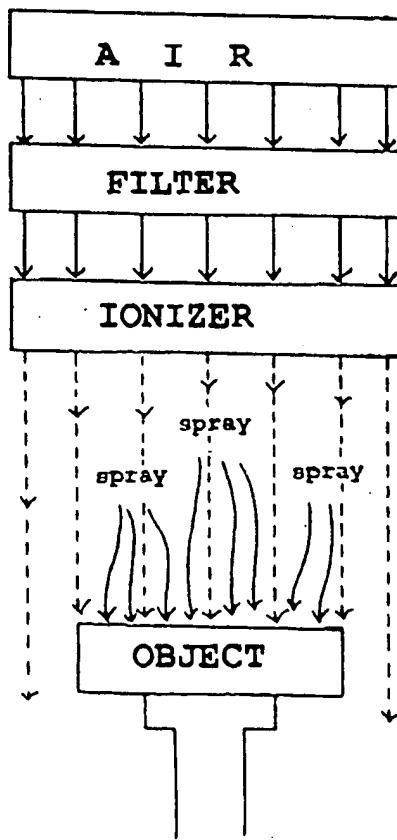
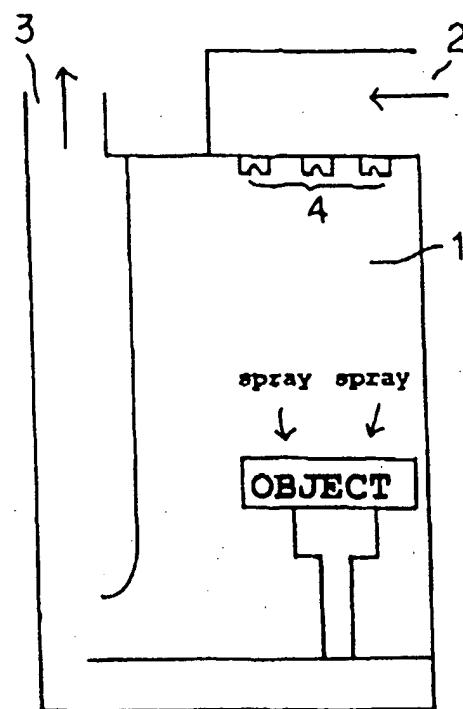


FIG. 3

(a)



(b)

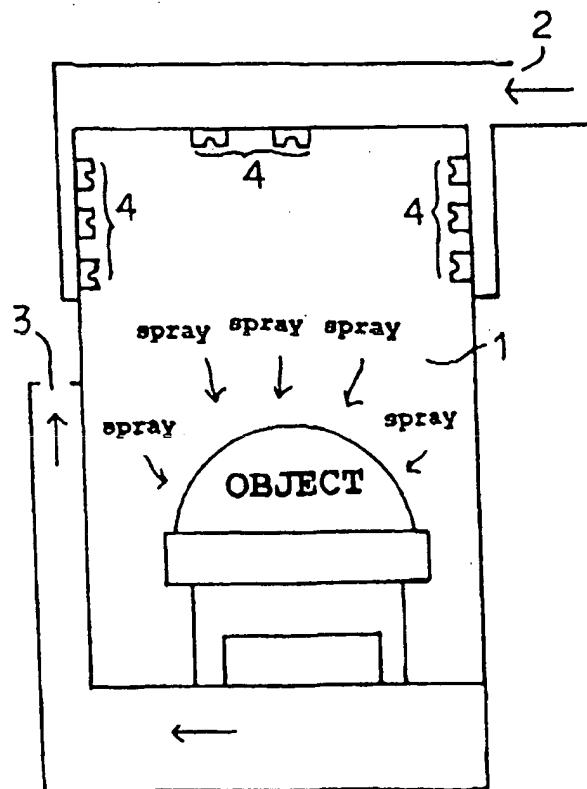


FIG. 4

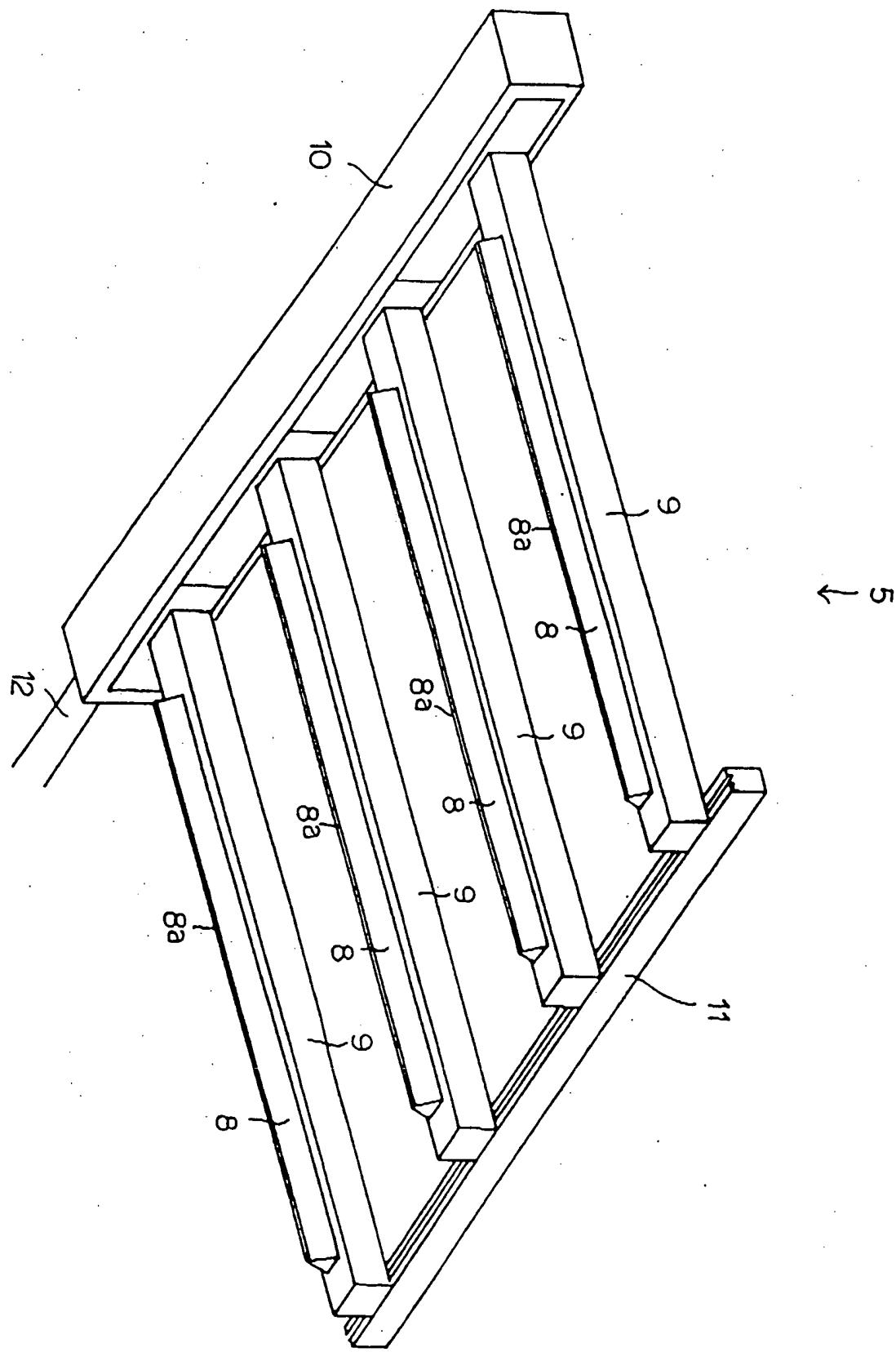


FIG. 5

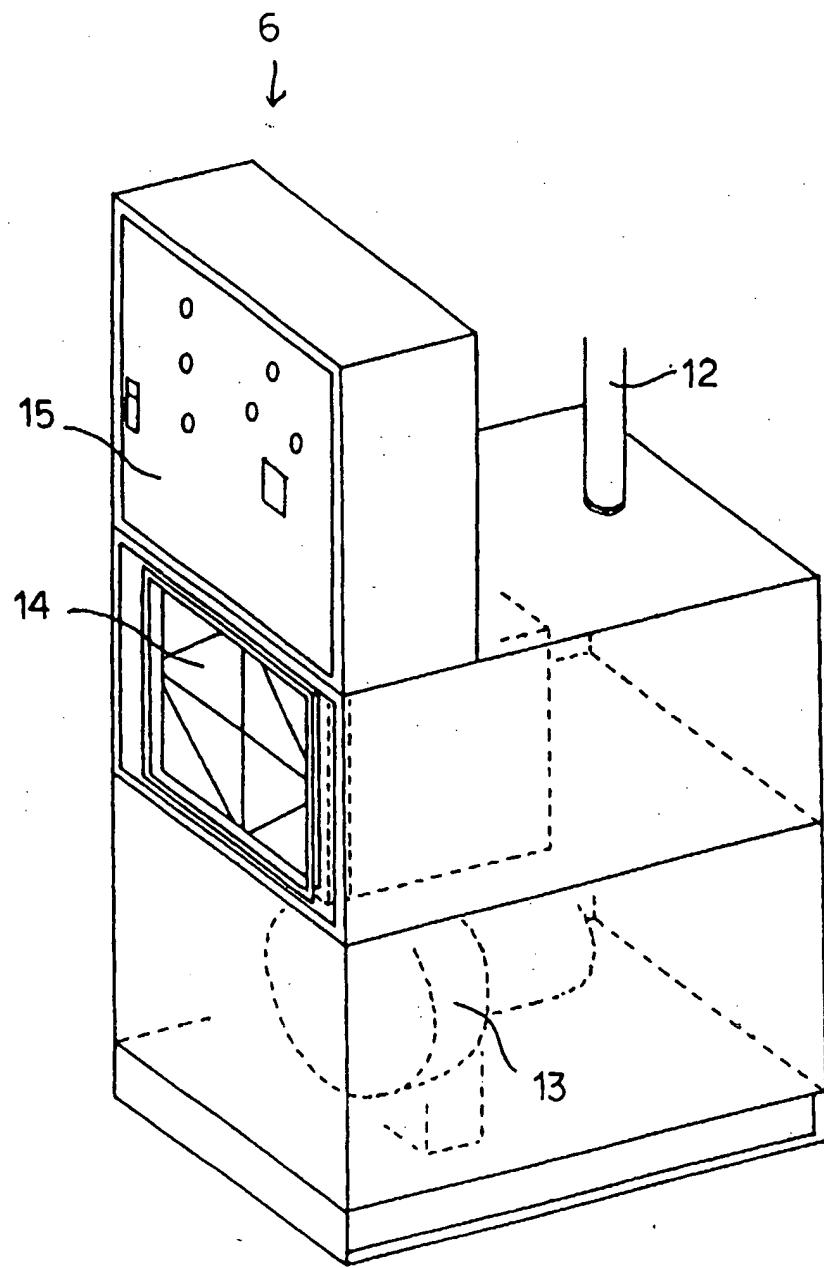
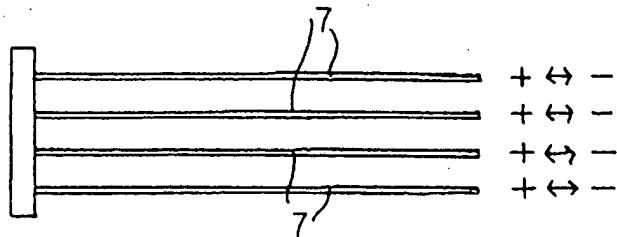


FIG. 6

(a)



(b)



FIG. 7

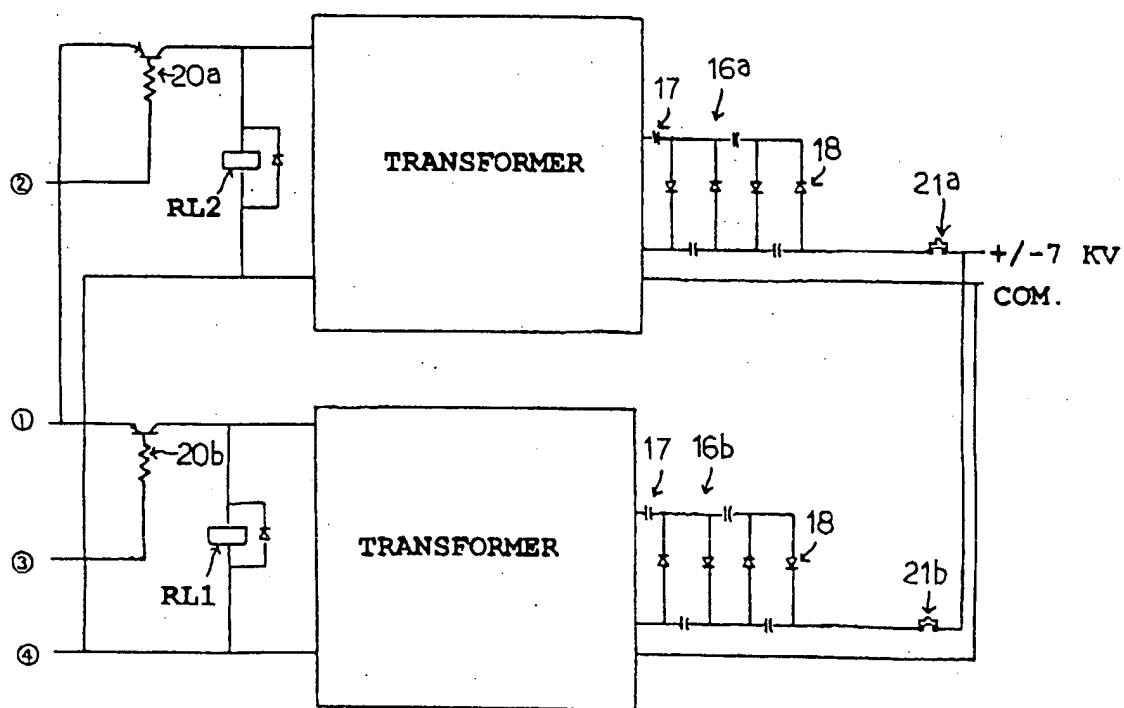


FIG. 8

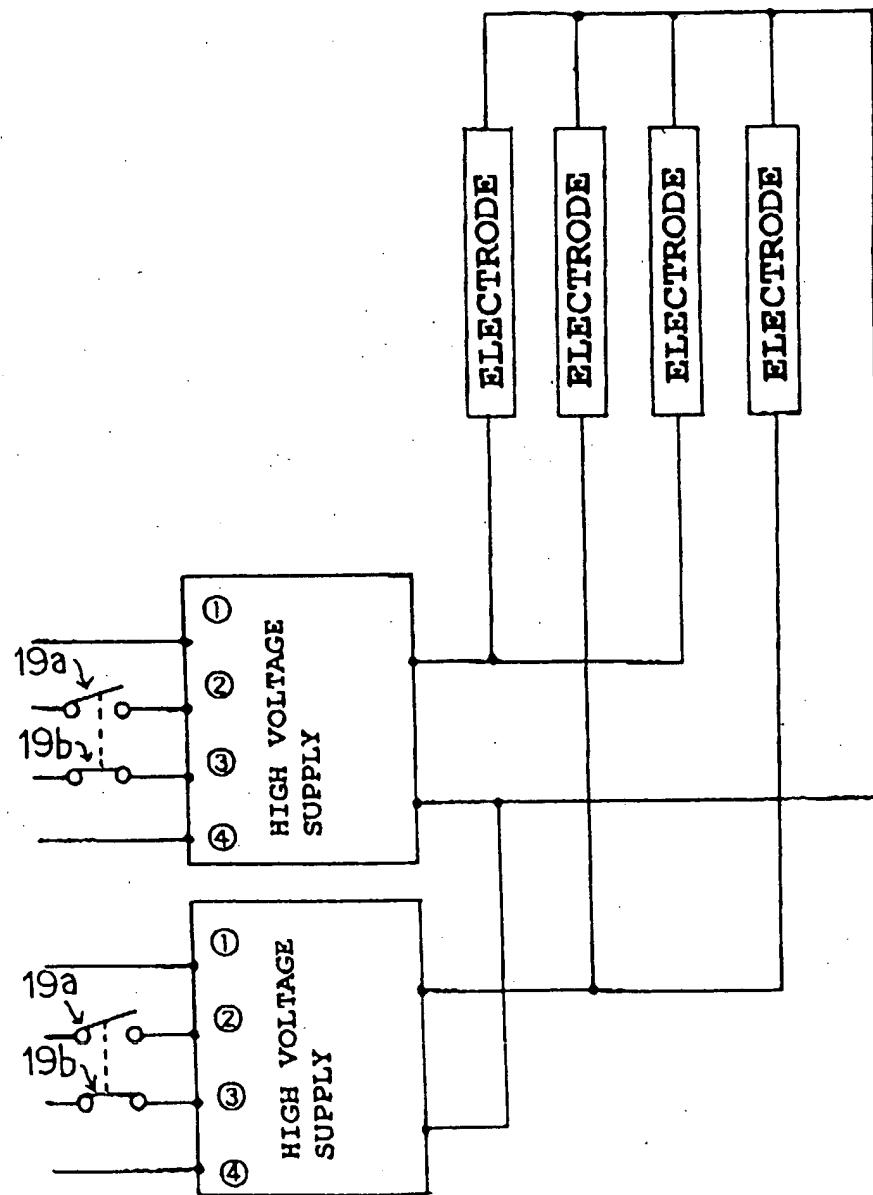


FIG. 9

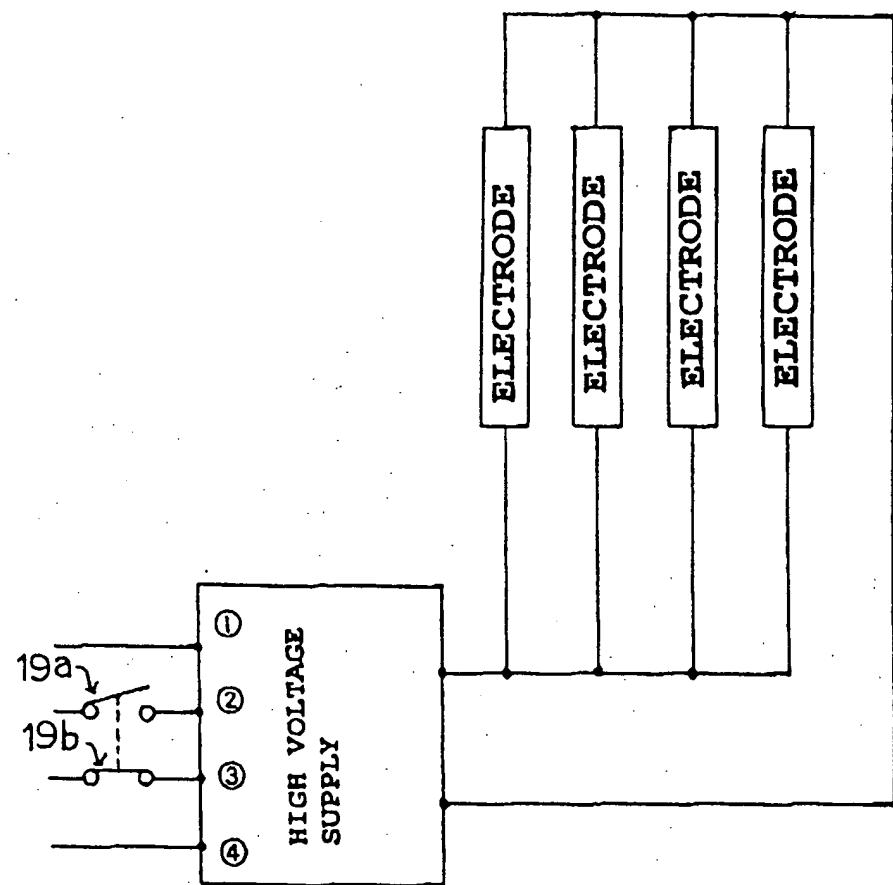
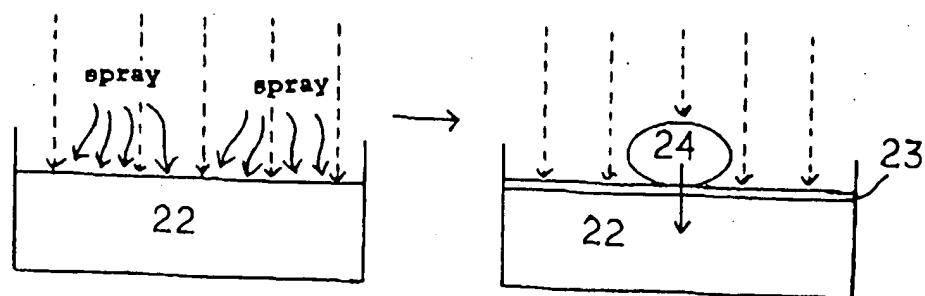


FIG. 10





European Patent  
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## EUROPEAN SEARCH REPORT

Application Number

EP 97 20 1855

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	DATABASE WPI Section PQ, Week 7615 Derwent Publications Ltd., London, GB; Class P42, AN 76-D4176X XP002048456 & SU 336 915 A (SANITARY TECH RES) , 3 October 1975 * abstract * & SU 336 915 A * figure *	1,10	B05D1/06 B05B5/08
A	US 5 567 468 A (LUCAS JOHN M) * the whole document *	1,10	
A	WO 84 03846 A (GEBHARDT MARIANNE E ;KOPPERSCHMIDT MUELLER & CO (DE)) * the whole document *	1,10	
A	EP 0 260 539 A (KOPPERSCHMIDT MUELLER & CO) * the whole document *	1,10	
A	FR 2 370 525 A (ONODA CEMENT CO LTD) * the whole document *	1,10	B05D B05B
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
Place of search		Date of completion of the search	Examiner
THE HAGUE		27 November 1997	Brothier, J-A
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application U : document cited for other reasons S : member of the same patent family, corresponding document	